Signal Detection Theory

Can we be sure it was a signal?

How do we know it’s the right signal?

How do we decide to act or not?

Signal detection theory is based on 3 assumptions: Neurons are constantly sending information to the brain, even when no external stimuli are present. This is called internal neural '**noise**.'

The level of neural noise fluctuates constantly.

When a faint (external) stimulus called a '**signal**' occurs, it creates a neural response which adds to internal noise

The brain must **decide** whether the neural activity it iss getting reflects noise alone, or whether there was also a signal.

Suppose a person is expecting an important visitor, someone that it would be unfortunate to miss.

The person is listening out and begins to "hear" the visitor, and may decide to go open the door, if nobody is there what was it? This is (internal) NOISE.

This person is "detecting" a signal that is not there because the decision is that it would be worse to miss than just check see if the individual is there. But it was a FALSE alarm, and clearly just noise.

What if the person was there? What do we have?

Our 3 components

1 Internal activity

Internal refers to the neural activity going on in the body all the time. So is called (neural) NOISE

2 External activity

External refers to all the activity coming in through the senses. But when it comes into the body , internal noise does not stop, the external adds to the internal =

NOISE + SIGNAL

These two components form the basis of SD, but there is also

3 decision CUT-OFF point

In a coffee shop, you see someone who looks familiar. Have you met him before?
These are examples of detection processes.
A common dimension of these situations is that there is uncertainty about whether a signal is present or not. That is, have you met the person before.

Should you go and talk to him at the risk of embarrassment if he's not? Or should ignore him at the risk of offending an acquaintance?

Both paths of action have potential costs and benefits and the correct decision is not clear. So, we establish our decision point (CUT – OFF)

Any decision you make may be biased by other experiences. If in the past you accidentally waved 'hello' to a stranger, you might be less likely to wave to the person who looks familiar.

Signal Detection Theory

- While we are at the mercy of our senses and how good they are
- We also have to make decisions about what action to take
- Decisions are dependent upon a number of things

Sensory Receptors

- **Exteroceptors**: sensory receptors that respond to light, sound, smell, touch, pain, etc., to create conscious sensation.

- **Proprioceptors**: sensory receptors that respond to joint movement (kinesthesia) and joint position (joint position sense), but do not typically contribute to conscious sensation.

For very intense signals, there is no problem in deciding if there was a stimulus because the neural effect of the signal far outweighs the neural effect of the noise.

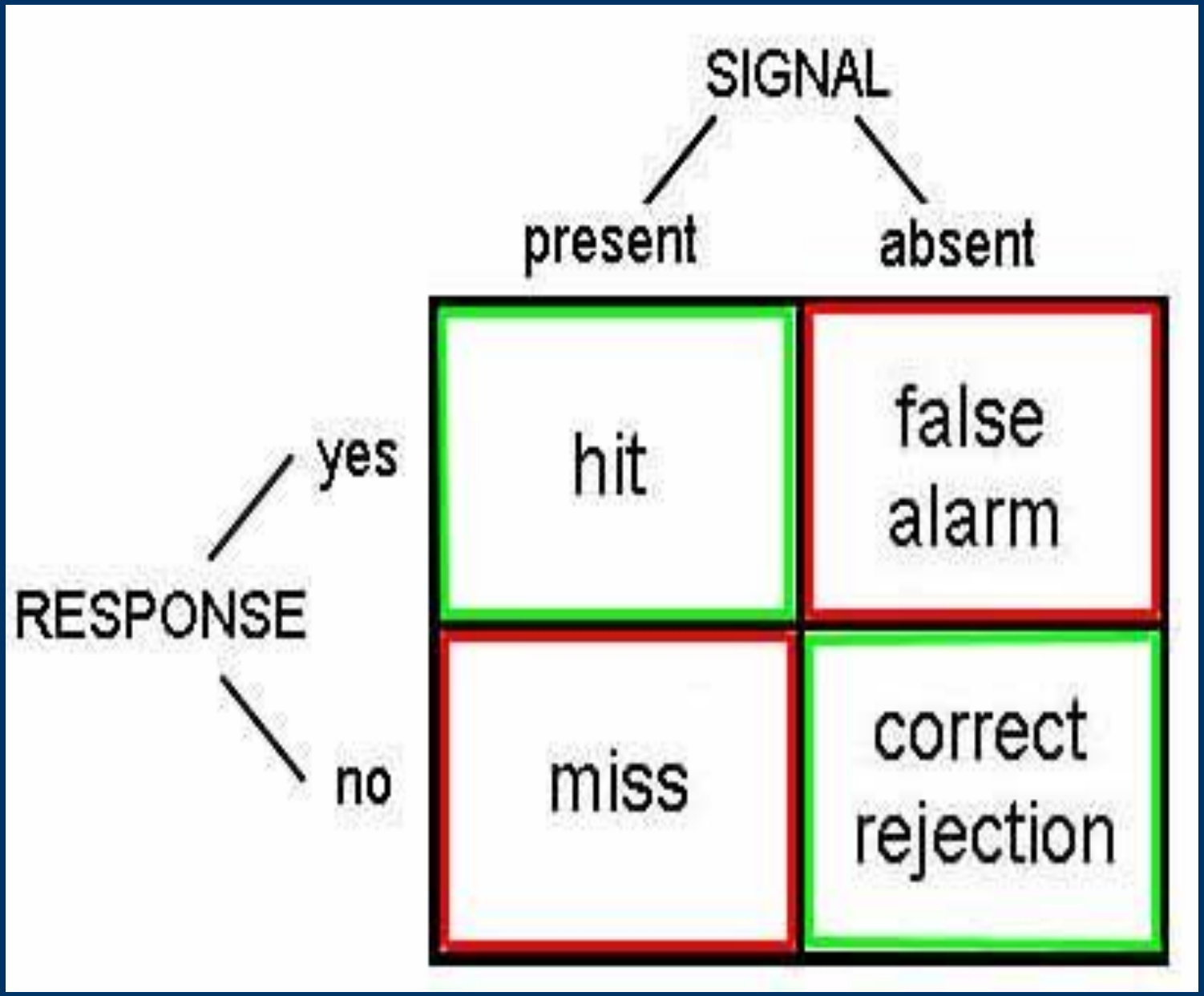
Similarly, when there is no signal, the nervous system does not respond as it does when an outside signal is present, so decisions are easy.

On the other hand, for near-threshold signals, it can be difficult to know whether neural activity results from noise alone or from a signal plus noise.

At this point, the observer makes a judgment (decision) based on the payoff matrix.

Judgement

- The performer has to make a decision based upon a judgement of the situational variables, and interpretation (judge) of the sensory information available within each situation


SIGNAL
present
absent
RESPONSE
yes
no
hit
false alarm
miss
correct rejection

If a signal is present and a person correctly identifies the signal, then she has made a 'hit.' (top left)

However, if the signal is absent and she says that the signal is present, then she has made a 'false alarm.' (top left)

If the signal present but she says it is not, she made a 'miss.' (bottom left)

If the signal is absent, and she says it's absent, she made a 'correct rejection.' (bottom right)

Signal Detection Theory

Seeks to explain why some decisions that are made are correct, while at other times a decision turns out to be incorrect.

SD seeks to explain the effect of internal ‘Noise’

And external Signal (confusion)

Signal Detection Theory

- SD also seeks to incorporate the effect of the judgement aspect of the decision making, and what is at stake for the performer.
- This is incorporated in the model as the ‘cut-off point’

Signal Detection Theory

There are three variables to consider:

- Internal activity (‘**Noise**’ in the system)
- Input from senses (environment), we call the **Signal**, which can sometimes be confusing
- Cut-off point (accept or reject)

Signal Detection Theory

- Internal Noise
  - Anxiety / stress raises internal activity
  - Uncertainty / confusion fires many neurons
  - Lack of experience / indecision

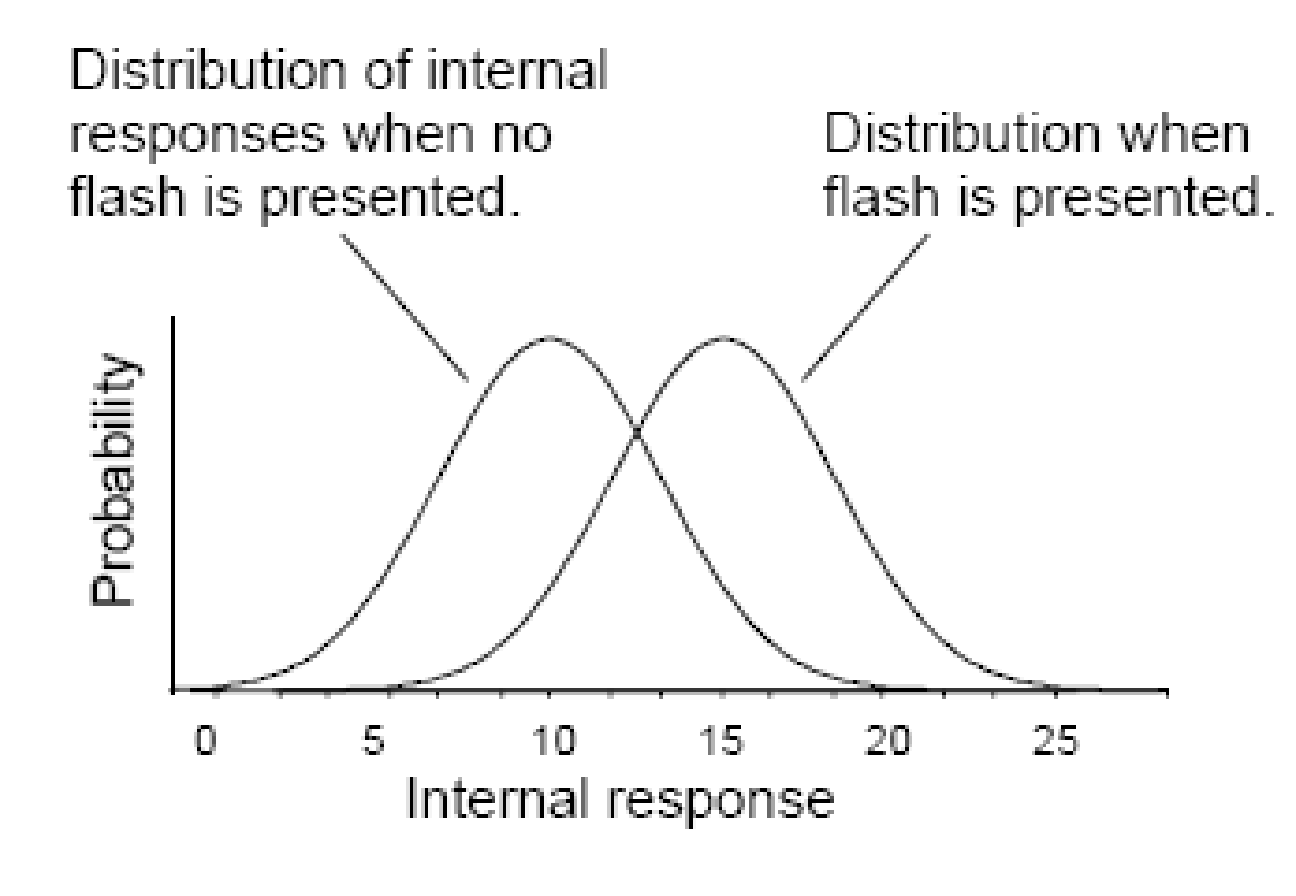
Signal Detection Theory

- External Noise
  - Weak signal
  - Confusion (competing signals)
  - Uncertainty (is it or not)
  - Lack of experience (looking wrong place, etc.)

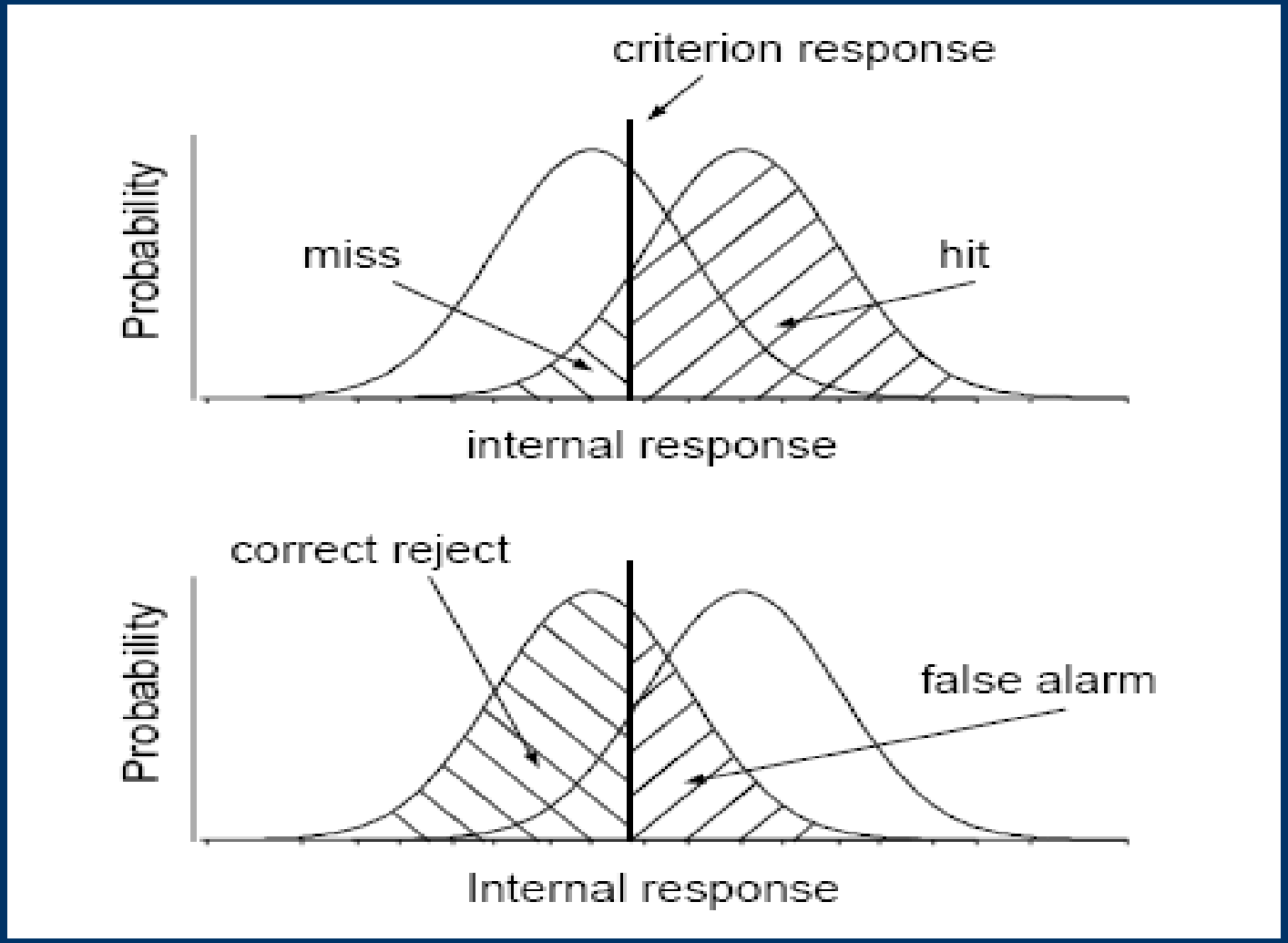
Signal Detection Theory

- Cut-off (accept / reject)
  - Experience
  - What's at stake

The Model
Noise and Signal

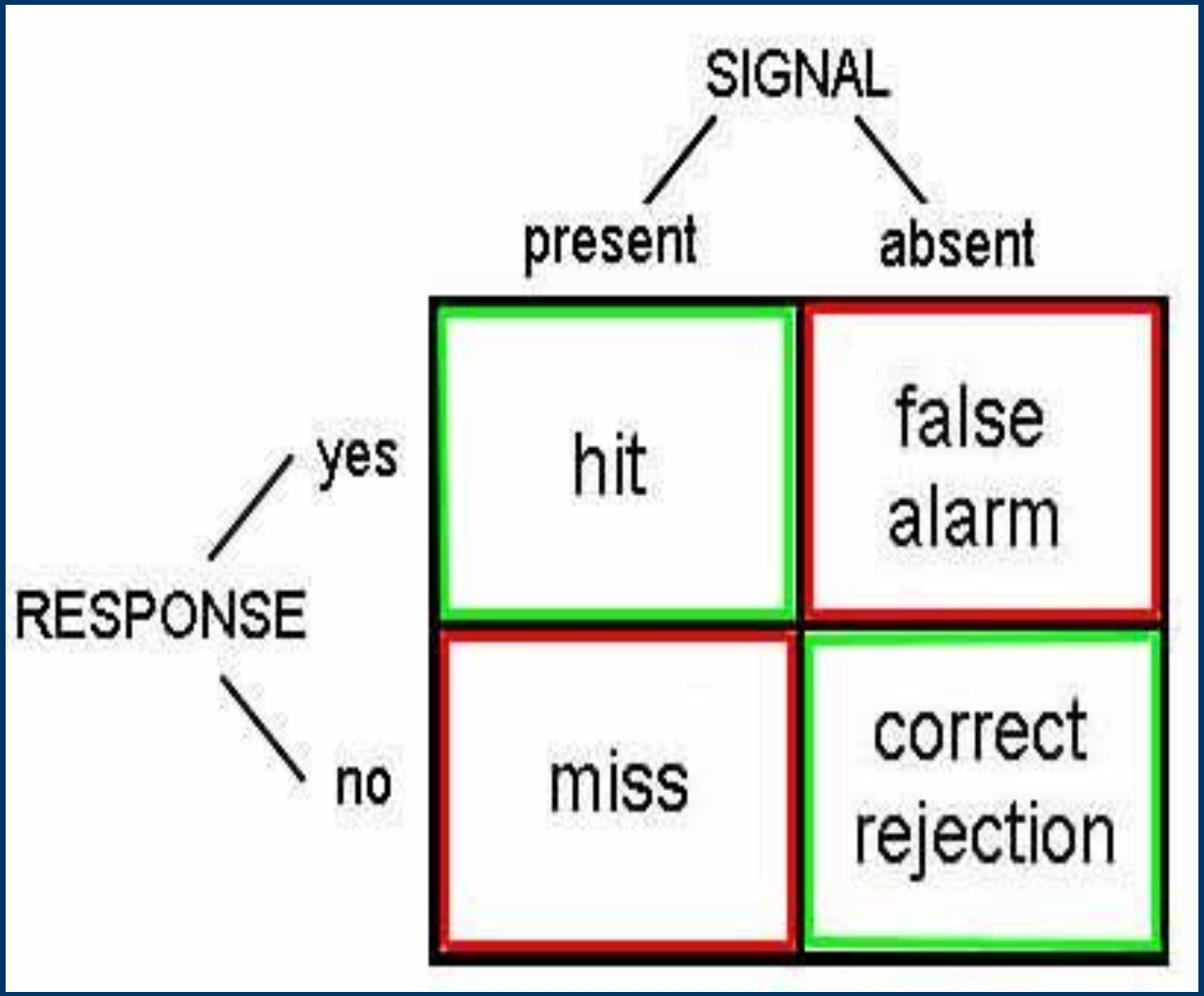


The Model

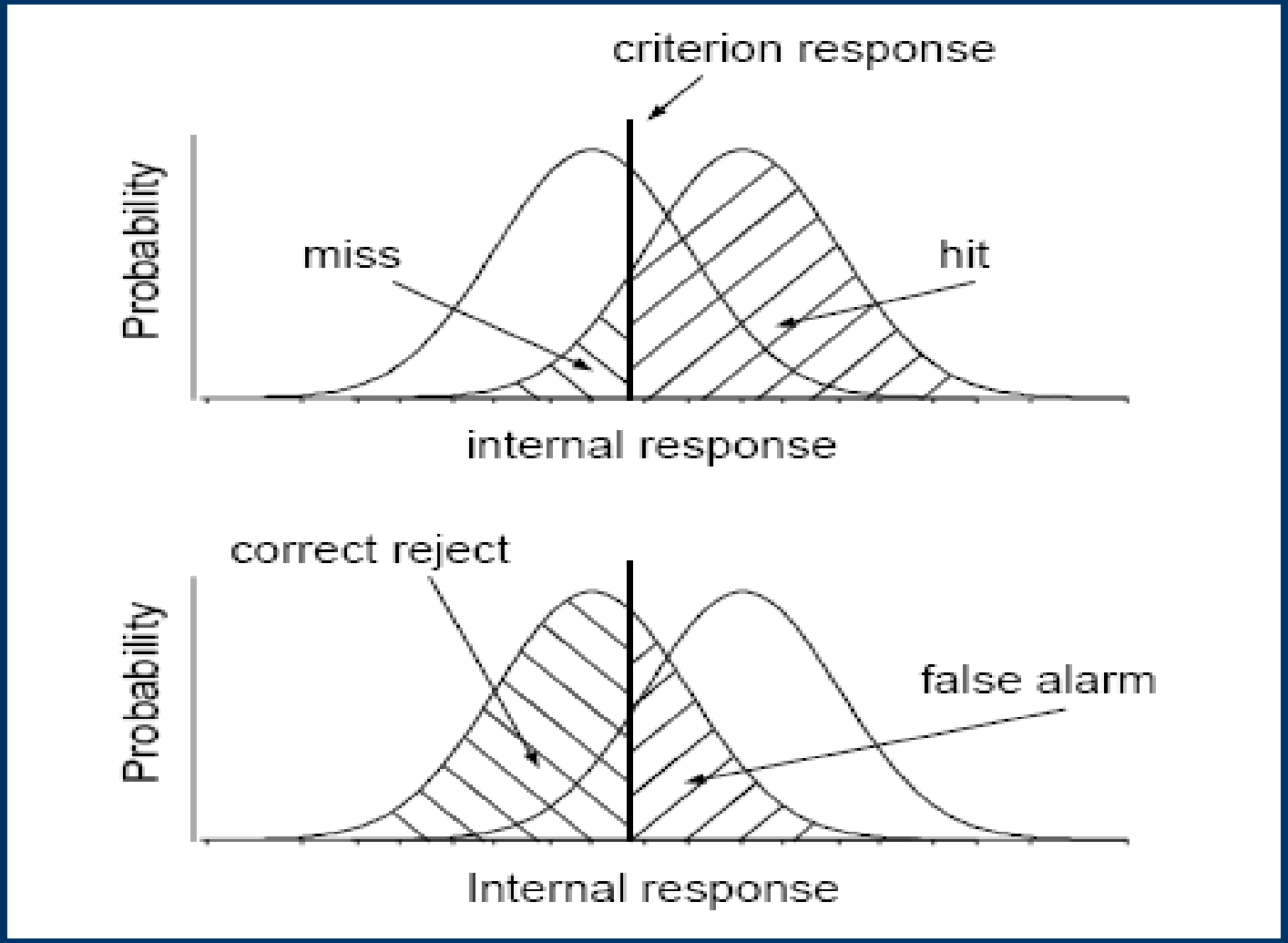

criterion response
Probability
miss
hit
internal response
correct reject
Probability
false alarm
Internal response

Possible Decisions

- Correct – signal, took action
- Correct – not a signal, did not take action
- Miss – said was not, missed something which was a signal, did not take action
- False – said it was a signal when it was not took action when should not (fake)


SIGNAL
present
absent
RESPONSE
yes
no
hit
false alarm
miss
correct rejection

The Model


criterion response
Probability
miss
hit
internal response
correct reject
Probability
false alarm
Internal response

Implications

Coach / teacher /trainer / participant adjust parameters:

- Internal noise
- Strength of Signal
- Cut-off point

Internal Noise

- Anxiety
- Inexperience
- Demands of task

Strength of Signal

- Experience
- Knowing what to expect
- Distractions (disguise)

Cut-off point

- Consequences
- Emotion
- Demand of task

The theory involves treating detection of the stimulus as a decision-making process, part of which is determined by the nature of the stimulus, by how sensitive a person is to the stimulus, and by cognitive factors.

In other words, a person will be able to detect more intense sounds or lights more easily than less intense stimuli.
Further, a more sensitive person requires less stimulus intensity than a less sensitive person would.

Finally, when a person is quite uncertain as to whether the stimulus was present, the individual will decide based on what kind of mistake in judgment is worse: to say that no stimulus was present when there actually was one or to say that there was a stimulus when, in reality, there was none.]]

Working Model

- http://cog.sys.virginia.edu/csees/SDT/index.html